21st CERES Science Team Meeting

--- Shashi K. Gupta, Analytical Services & Materials, Inc., Hampton, VA 23666 (s.k.gupta@larc.nasa.gov)
Gary G. Gibson, NASA Langley Research Center, Hampton, VA 23681-2199 (g.g.gibson@larc.nasa.gov)

The 21st Clouds and the Earth's Radiant Energy System (CERES) Science Team meeting was held in Hampton, VA on May 2-4, 2000. The team decided that Edition 2 ERBE-Like (ERBE is the Earth Radiation Budget Experiment) Tropical Rainfall Measuring Mission (TRMM) data are ready to archive and release with the updated data quality summaries. The Edition 1 Single Satellite Footprint (SSF) TRMM data product is in good shape, with only a few changes needed before starting archive and distribution in about 2 months. The next CERES Science Team meeting is scheduled for September 20-22, 2000 at the University of Alabama - Huntsville.

Bruce Wielicki (LaRC), CERES Co-Principal Investigator, opened the meeting with an Earth Observing System (EOS) program status report. The official Aqua launch date is December 2000. He also briefed the team on a recent NASA exercise to establish a vision for the next 25 years of Earth Sciences space missions and technology needs.

CERES Instrument Status

Larry Brumfield (LaRC) presented the Aqua instrument status report. The CERES instruments were delivered to the Aqua spacecraft in early January, mounted onto the spacecraft, and are ready for integration and testing. Kory Priestley (LaRC) delivered the CERES/Terra Flight Models 1 & 2 (FM1 and FM2) validation status report. Early results demonstrate ground-to-flight radiometric stability of better than 0.5, 0.4, and 0.25% for the window (WN), shortwave (SW), and total channel pairs of radiometric sensors. Coastline detection algorithms demonstrate mean navigational accuracies at the 1-km level. Three-channel intercomparison, and deep convective albedo studies suggest the Terra and TRMM instruments are on the same radiometric scale with confidence bounds at the sub 1% level.

Richard Green (LaRC) presented Tropical Mean intercomparison results for March 2000 showing consistency between the FM1, FM2, and TRMM Proto Flight Model (PFM) at the 0.5% level for nighttime LW and at 0.1% between FM1 and FM2 SW. **Martial Haeffelin** (Virginia Tech) highlighted preliminary results from TRMM/Terra matched view zenith/relative azimuth intercomparison studies. The CERES instruments on the two spacecraft are in agreement to within 0.4% and 0.5% for SW and longwave (LW) radiance, respectively.

Kory Priestley summarized operations for the TRMM PFM instrument's return to service. Operational power was restored on February 25, 2000 and nominal science data collection in the cross-track mode was begun February 26th. Attempts to transition to biaxial operations saw sluggish azimuth gimbal performance; recovery operations to exercise the gimbal were completed in mid-March. Beginning on March 13th the primary science channel output began experiencing 'contamination' from an unknown electronic source. Suspicion lies with the failing Interpoint voltage converter. Diagnostic studies are underway. Initial results suggest that the data are recoverable, and that the noise can be eliminated in future data collection.

Bruce Barkstrom (LaRC), CERES Co-Principal Investigator, discussed the need for deep space observations on Terra and Aqua. CERES has sample-dependent offsets, and the only rigorous approach to determining offsets is observation of deep space. However, other instruments on Terra and Aqua have some concerns about making deep space observations. ASTER (Advanced Spaceborne Thermal Emission and Reflection) on Terra is worried about solar incidence, and AIRS (Atmospheric Infrared Sounder) on Aqua is concerned about thermal stability of calibrations.

CERES Data Systems

Bruce Barkstrom highlighted two new data system issues. First, the Earth Science Enterprise (ESE) recently announced that they would implement recovery of full marginal cost of data products. Second, the ESE is proceeding to explore long-term archival of EOS data with NOAA.

Jim Kibler (LaRC) updated the team on the Instrument Simulator, a new version of the view_hdf tool, data and code deliveries, and data product versions. The TRMM and Terra simulators are operational and are being used for testing and validation of command sequences, scan tables, software patches, and long command uploads. The Aqua simulator is under development. Dealing with

the TRMM and Terra data flow has been a challenge, but the team is identifying the problems and successfully handling the large volume of data.

CERES/TRMM ERBE-like Data Products

Kory Priestley presented the final spectral response functions used in the Edition 2 ERBE-like products. **David Young** (LaRC) reviewed recent algorithm improvements and the current status of the ERBE-like products. The Edition 2 ERBE-like TRMM data are ready to archive and release with the updated data quality summaries.

CERES/TRMM SSF Data Product

Patrick Minnis (LaRC) summarized recent changes to the CERES cloud algorithm including a variety of improvements in nighttime and twilight retrievals and a new five-band application of correlated k distribution techniques to account for atmospheric absorption across the Visible Infrared Scanner (VIRS) and Moderate-Resolution Imaging Spectroradiometer (MODIS) 3.7µm bands. He presented comparisons of cloud properties derived using European Center for Medium-Range Weather Forecasts (ECWMF) and GSFC's Data Assimilation Office (DAO) data in the Meteorological, Ozone, and Aerosol (MOA) data base. He presented an extensive set of cloud property validation data sets and consistency checks. Results from the integration of Ron Welch's methods for determining cloud cover, aerosols, and smoke were shown. An intercomparison of cloud properties derived using techniques of Minnis, Jim Coakley (Oregon State University, OSU) and Qingyuan Han (University of Alabama–Huntsville, UA-H) was presented. Tom Charlock (LaRC), Norman Loeb (Hampton University, HU), and David Kratz (LaRC) showed results which confirmed the validity of the SSF clear-sky fluxes; however, several problems with the cloudy-sky fluxes were noted.

The team concluded that several changes are needed prior to archiving the TRMM Edition 1 SSF data product. The calibration of the 1.6µm VIRS channel should be changed to be consistent for both the cloud algorithm and aerosol optical depth (AOD) retrieval. A channel 1 reflectance variability test will be added to remove sub-pixel cloud contamination from the 2km VIRS pixels used to determine cloud optical depth. Three new parameters will be added: fraction of VIRS pixels and average reflectance of VIRS pixels (0.63 and 1.6µm) in the CERES field of view (FOV) used to determine the AOD. A 10-minute land/water mask will be used instead of the 2.5-degree mask to avoid eliminating many AERONET validation sites. Minnis, Coakley, and Han will intercompare radiative model calculations at 3.7µm to resolve particle size method retrieval differences.

The team decided that, in addition to the cloud and aerosol retrievals, only the clear-sky fluxes should be included on the SSF. More TRMM scanner data are required to develop the new angular models for cloudy conditions. Meanwhile, users will have improved (relative to ERBE) cloud screening and clear-sky fluxes. Clear-sky will be defined as 0% cloudy pixels in the FOV.

Cloud Working Group

Patrick Minnis led discussions of cloud retrieval, archival, and validation issues. The group agreed that cloud fraction and cloud pressures were ready for the first archiving of cloud property retrievals. Optical depth, water path, and particle sizes were also recommended for archiving, but with the caveat that these properties during twilight and nighttime hours should not be considered as reliable. A new delivery to the DAAC will be made near July 2000. That delivery will attempt to address some of the differences in effective water radii found by VISST and by Coakley's methods. Coakley, Minnis, and Han will compare their respective radiative transfer calculations to eliminate the possibility that the radii differences are due to model differences. Larry Stowe (NOAA) led a discussion of initiating further screening of the clear-sky aerosol data to eliminate cloud contamination. The existing cloud adjacency test may also be invoked for aerosol pixels.

Ron Welch (UA-H) demonstrated a new version of the satellite data display and analysis tool Interactive Visual Image Classification System (IVICS). He presented several analyses of VIRS data using IVICS and his image classification methods that utilize neural network techniques. The group discussed using IVICS to access the CERES pixel-level output for use in doing validation and inter-algorithm comparisons. The LaRC cloud group agreed to facilitate making pixel-level products available over validation sites.

Mike Friedman (Oregon State University) gave a progress report on pixel-scale water cloud retrievals. He identified mid-latitude water clouds as having the largest particle size differences between their retrieval and those retrieved with the CERES cloud algorithm. He also presented additional results from their retrieved cloud properties in partly cloudy pixels.

Q. Han (UA-H) analyzed variations in ice cloud property retrievals due to phase functions that are assumed in the modeling process. He noted that the thermal signal dominates in thin ice clouds while the solar component is dominant in thicker ice clouds. He cautioned that the signature of ice clouds in both thermal and solar wavelengths was small enough to induce large errors in retrieved particle sizes. Also discussed was the sensitivity of the retrievals to assumed particle size distributions, particle shapes, and aspect ratios. Han then summarized his validation efforts, including recognizing the need for additional validation in optically thin ice clouds.

Kazuaki Kawamoto (Virginia Tech) discussed improved techniques that are being used in SIST, the nighttime CERES cloud retrieval, to allow for retrieval of cloud properties when temperature inversions are present. He indicated that the retrieval is sensitive to the accuracy of the predicted clear-sky temperature, but that first results are encouraging.

Xiquan Dong (University of Utah) summarized CERES cloud property validation activities using surface data taken at the SHEBA (Surface Heat Budget of the Arctic) ship during the FIRE Arctic Cloud Experiment (ACE) and for 2 years of data taken at the Atmospheric Radiation Measurement (ARM) Southern Great Plains (SGP) site. For SHEBA, he compared Advanced Very High Resolution Radiometer (AVHRR) derived cloud temperatures and heights to surface-based retrievals of cloud properties at the SHEBA ship. He validated both ice and water cloud properties over the SGP site.

Ben Ho (Analytical Services & Materials, Inc., AS&M) compared liquid water path (LWP) retrievals from coincident VIRS and TRMM Microwave Imager (TMI) data. For non-precipitating warm clouds, the LWP derived from the two instruments compared well. Over ice clouds, the comparisons were weaker, possibly indicating the influence of overlapped clouds on the retrievals.

Seiji Kato (Hampton University) compared VIRS-derived LWPs to those derived with a technique that combines radar and microwave radar data sets over the ARM SGP site. He found that the mean VIRS derived LWP was larger than the radar-derived LWP. He presented an analysis of the variation of LWP in both data sets in order to investigate the differences.

Surface and Atmospheric Radiation Budget (SARB) Working Group

The meeting was led by **Tom Charlock** and **David Kratz**.

David Rutan (AS&M) presented the new on-line database for the CERES ARM Validation Experiment (CAVE) which was developed to facilitate validation of CERES-derived surface fluxes. It consists of flux measurements from ARM, BSRN, SURFRAD, and other high-quality surface sites from around the world which are matched in space and time with satellite retrievals over the sites. Meteorological data for the sites necessary for making radiative transfer calculations are also a part of the database. Site measurements are presented in a standardized format as 30-minute averages. This database will be made available in the near future to science community from the CAVE web site at:
www-cave.larc.nasa.gov/cave.

David Kratz (LaRC) presented results of the validation of CERES surface longwave fluxes obtained from the surface-only LW Model-B (Gupta model). CERES fluxes were compared with measurements from several ARM, BSRN, and CMDL ground sites. Kratz identified physical causes for the large differences observed at some sites and known instrument maintenance problems at some others. He presented results for January, April, and July 1998 and showed that random errors of about 20 Wm^{-2} were achievable for instantaneous comparisons. Systematic errors were found to be in the 5-10 Wm^{-2} range.

V. Ramanathan (Scripps Institution of Oceanography, SIO) presented results of CERES validation with measurements obtained from the Indian Ocean Experiment (INDOEX). These measurements were made at the Kaashidhoo Climate Observatory (KCO) in the Republic of Maldives. CERES TOA albedos were in good agreement with theoretical estimates at the KCO for solar and view zenith angles less than 50 degrees. Ramanathan showed the estimates of aerosol radiative forcing (ARF) efficiency to be about –25 Wm^{-2} per unit AOD. Estimates of ARF derived from edition 1 and edition 2 ES-8 data differed by 2-3%. He also showed that ARF efficiency increased with solar zenith angle and varied from -24 to -28 Wm^{-2} per unit AOD.

Bob Wheeler (AS&M) apprised the group of the LaRC-developed airborne measurement capabilities to support CERES activities. He presented results from

two aircraft measurements coincident with Terra overflights. These measurements were obtained from the uplooking and downlooking PSP, PIR, and a spectral radiometer mounted on the OV-10A aircraft flown over ocean near the CERES Oceanic Validation Experiment (COVE) site. Wheeler showed a time-wavelength cross section developed from measurements by the spectral radiometer flown at a height of 150 meters above the water surface.

Tom Charlock (LaRC) presented a brief description of the ongoing effort for measuring spectral SW reflectances of the ocean surface at the CERES Ocean Validation Experiment (COVE) site. This site is located at a Lighthouse platform in the Atlantic ocean off the coast of Virginia Beach, VA. Measurements are made with a Schulz spectrophotometer. The results are being used to develop new spectral bidirectional reflectance distribution functions (BRDFs) for the ocean surface, and to validate the BRDFs being used in CERES processing. These measurements will also be used to examine the variability of surface optical properties with waves and winds over the ocean surface.

Fred Rose (AS&M) presented results of recent improvements to the Fu-Liou radiative transfer code made in close consultation with Qiang Fu. The changes include improved treatment of Rayleigh scattering, ozone and aerosol extinction, and surface albedo. Rayleigh scattering is computed separately for 10 bands and correlated-k coefficients were revised for the ozone bands. Changes in Rayleigh scattering treatment resulted in an increase in direct radiation and a decrease in diffuse radiation. Changes in ozone treatment affected the TOA albedo. The new aerosol optical depths are taken from GFDL monthly climatologies, and are wavelength dependent. Rose also showed the effects of these aerosol changes. It is planned to introduce Collins-Rasch aerosol assimilations into SARB processing. Changes to the surface albedo determination include the use of modified Staylor-Wilber method over land areas and Yong Hu's method over oceans.

William Collins (NCAR) presented results of a global assimilation model which may provide estimates of aerosol optical depths (AODs) for use in SARB processing. A chemical transport model (CTM) was used with emission sources of sulfate, sea-salt, soil-dust, and black and organic carbon aerosols. Biomass burning and other land-based sources of carbon and sulfate aerosols were taken into account. Satellite retrievals over oceans were also assimilated in the CTM. The assimilation process enhances the quality of aerosol products, especially over land areas where there are no satellite retrievals. Results will be provided for testing and use in SARB processing. It is also planned to assimilate spectral AODs and LIDAR data into the model to forecast aerosol vertical profiles.

Yaping Zhou (AS&M) presented results on spectral fluxes and BRDFs obtained during the CERES ARM Radiation Experiment (CARE) conducted at the ARM SGP site in August 1998. These measurements were made by a spectral radiometer flying on a helicopter at a height of 300m over many types of cropland. The measurements were reduced to surface and TOA BRDFs by applying atmospheric corrections. In situ measured temperature, humidity, and aerosol profiles, TOMS ozone, and AODs from MFRSR were used in the atmospheric correction process. A total of 31 BRDFs were measured and analyzed. Comparisons of measured and derived upwelling and downwelling fluxes showed good agreement.

Angular Distribution Model (ADM) Working Group

Norman Loeb led the ADM working group meeting with a general overview of critical ADM/inversion research issues. **Yaping Zhou** presented spectral flux and BRDF results from the CARE. This presentation was essentially the same as that presented to the SARB Working Group.

Dave Doelling presented results from an ongoing study that seeks to account for changes in regional cloud amount between CERES broadband measurements using 3-hourly geostationary measurements. One aspect of the method requires a conversion of narrowband GOES radiances to broadband fluxes. The geostationary narrowband data are calibrated against the onboard CERES imager. The CERES imager and broadband flux data are used to derive empirical narrowband to broadband equations on a regional basis. Because the geostationary and imager narrowband channels have different spectral response functions, time coincident and angle matched VIRS (CERES imager during 1998) and GOES-8 narrowband albedos had seasonal and diurnal trends over the ARM SGP site. GOES-8 visible (0.5-0.8μm) albedos were greater than the VIRS (0.55 to 0.68μm) during the growing season because plants have a greater reflectivity in the near IR (0.7-1.1μm) than in the visible. A more puzzling result was that the GOES-8 morning albedos were greater than the afternoon albedos with respect to VIRS. If the GOES-8 albedos are matched to the exact angles of VIRS with the use of bidirectional

models the diurnal bias decreases. CERES CARE data taken over the ARM-SGP site during the morning hours of August 1998 was used to construct albedo directional models. The high-resolution spectral data was weighted by the spectral response function of VIRS and GOES-8 and the incoming solar radiation. The ratio of GOES-8 and VIRS revealed a 10% increase in albedo at 55 degrees compared to 25 degrees solar zenith angle. One would need afternoon data before drawing any conclusions.

Nitchie Manalo-Smith (AS&M) presented cloud-free longwave and window limb darkening functions obtained from CERES measurements. She demonstrated one technique (matrix-ratio-method) that can be used to fill missing angular bins. She also examined the sensitivity of clear ocean and land LW and WN ADMs to precipitable water, lapse rate and surface temperature.

Using CERES SSF data from 80 days, **Norman Loeb** examined the influence of variable FOV size on the all-sky mean albedo from CERES VIRS12 ADMs ADM-derived albedos showed a ~10% decrease with viewing zenith angle, likely due to the variable footprint size. Spatially averaging footprints by keeping the along-track dimension fixed at 60-km (while the cross-track dimension remained unchanged) improved the results only slightly. It was argued that removal of this viewing zenith angle bias in the all-sky albedo may require a redefinition of ADM scene types which have a frequency of occurrence that is independent of viewing zenith angle.

Sandra Nolan (SAIC) outlined the procedure for CERES SSF processing and provided the group with a skeleton step-1 implementation strategy for CERES SSF inversion.

Investigator Presentation Highlights

Robert Cess (State University of New York at Stony Brook) presented results from a study of the impact of El Nino on cloud radiative forcing (CRF) over the warm pool region. He compared CERES-derived SW and LW CRF for January-August 1998 with corresponding ERBE-derived values for the same months in 1985-89. The SWCRF/LWCRF ratio, N, which was close to unity for the ERBE years, was considerably higher (about 1.3) for 1998. Cess suggested that this increase in N was related to the 1998 El Nino episode. He hypothesized that deep convective clouds over the warm pool region thicken during El Nino episodes leading to stronger SWCRF and higher values of N. Cess also explored the relationship between N and the tropopause temperature and found significant differences between ERBE years and 1998.

Si-Chee Tsay of GSFC (representing **Mike King**) presented results from a study of thermal characterization of pyranometers and pyrgeometers used in surface and atmosphere energetics measurements. He outlined the role of these instruments in climate research and in validating satellite retrievals of surface radiative fluxes. He emphasized the importance of the absolute calibration of these radiometers for establishing accurate long-term trends of surface fluxes. Tsay briefly reviewed the evolution of thermopile technology in the U.S. and in Europe and showed how dome characteristics affect the radiation balance between the sensor and the target. He defined the dome factor as the ratio, emissivity/transmissivity, and found that uncertainty in the dome factor can affect the IR irradiance measurements by 10-15 Wm^{-2}. He concluded that it is critical to measure both case and dome temperature to accurately characterize the radiometers.

Marat Khairoutdinov of Colorado State University, CSU (representing **David Randall**) presented comparisons of CSU General Circulation Model (GCM) simulations of TOA radiation fields with corresponding CERES measurements. Comparisons were shown for reflected SW and OLR fields for the months of Feb-Mar and Jul-Aug 1998. The radiation module in the CSU GCM has been replaced by a new module named 'BUGSRad', which is based on the Fu-Liou radiation code and uses anomalous diffraction theory. Comparisons show that CSU GCM reproduces most features of the observed fields quite well. Comparisons of precipitable water fields in the new model with those in the old version, and with NVAP observational data showed significant differences. A numerical experiment simulating flights of TRMM, Terra, and Aqua over model fields was conducted to determine if the three satellites flying together for a month can capture the complete diurnal cycle of the radiation fields.

Bryan Baum (LaRC) presented early results on cloud properties retrieved using data from MODIS which is on board the Terra satellite. He indicated that images from MODIS are available on the world wide web in near real-time. Baum briefly described the MODIS instrument and showed the earliest images obtained over different parts of the globe. High-resolution images over the Great Lakes region clearly showed cirrus clouds, and those off the coast of California showed exhaust plumes along the ship

tracks. Analysis of images over Africa showed that the presence of heavy smoke/dust suppressed the development of low clouds. Baum also showed retrievals of amount, height, optical depth, and drop size distributions obtained for the March 2000 IOP over the ARM CART site in Oklahoma. Retrievals closely matched the images. He also showed comparisons of MODIS results with those derived from GOES data.

Tom Charlock (LaRC) presented methodology and results of an effort to retrieve surface albedo from CERES/TRMM data. He outlined the retrieval procedure and listed the factors that affect the results. He listed AOD as one of most important and least certain factors. Charlock presented some results from the CARE experiment conducted during August 1998 near the ARM SGP site which showed an increase in broadband surface albedo with solar zenith angle. Similar increase was also observed in CAVE data. Several sources of AOD have been tried in CERES/SARB albedo retrivals, including GFDL climatology and the Collins-Rasch 6-hour assimilations. Charlock showed results derived from CERES ERBE-like ES-8 data for four IGBP surface types.

Jim Coakley (Oregon State University) presented results on the determination of direct aerosol radiative forcing (ARF) from data obtained during the INDOEX. Aerosol optical depths (AOD) over the INDOEX region were derived from NOAA-14 AVHRR data using the 2-channel method and results were compared with AERONET observations from the Kaashidhoo Climate Observatory (KCO). Coakley showed relationships between AOD and direct ARF and the changes in AOD from March 1996 to the present. Direct ARF derived from AVHRR data were also compared with CERES single satellite footprint (SSF) results. Coakley found that CERES retrievals were generally higher than AVHRR values. He suspected that most of the analyzed footprints were cloud contaminated

Ron Welch (University of Alabama, Huntsville) presented results from a study of biomass burning and smoke ARF over South America and Africa using TRMM data. Smoke pixels were identified from VIRS data, and smoke AOD and single scattering albedo (SCA) were retrieved for these pixels. Satellite retrievals were used to construct smoke ADMs and estimate smoke ARF at the TOA. These were also compared with aircraft measurements. Welch presented comparisons of computed surface insolation with corresponding PSP measurements over a biomass buring region of South America. Smoke AOD over this region were found to be as high as 2 to 3 and SW ARF at the TOA as large as 20 to 50 Wm^{-2}. Corresponding ARF values at the surface were 100 to 500 Wm^{-2}.

Bill Smith, Jr. of AS&M (representing **Pat Minnis**) presented results of near real-time retrievals of cloud properties over the ARM SGP site to support field experiments. This was accomplished by applying CERES cloud algorithms to high-resolution (30 min., 4 km) GOES data. The objective is to produce a continuous record of cloud properties over the ARM site from 1995 to the present. The algorithms use VIS and IR data during the day and IR only during the night. Hourly surface temperatures used in the retrievals were obtained from global reports. Smith showed movies of cloud properties over the SGP site retrieved during ARESE-2 IOP in the spring of 2000. Results obtained to support the INCA field experiment in South America were also shown. It is planned to expand this effort to cover the entire continental U. S.

Larry Stowe (NOAA/NESDIS) presented comparisons of AODs derived from VIRS channel 1 using CERES/SSF data and channel 1 of the AVHRR. Direct comparisons of AOD retrievals from the second channel of both instruments were not done because of the difference in their wavelengths. Stowe reported that AOD derived from VIRS data was about 0.05 higher than from AVHRR. The range of AODs derived from AVHRR was much wider. Retrievals from channels 1 and 2 of VIRS were found to be consistent with each other. The Angstrom exponent between the two channels was found to be within expected range. Stowe also reported that an error occurred in the Rayleigh OD computation during the changeover from Dave code to the 6S radiative transfer code. The error has since been corrected but it has not removed the bias. AOD from VIRS data were also found to be higher than those from AERONET observations.

Steven DeWitte (Royal Meteorological Institute, Belgium) presented status reports on DIARAD/VIRGO instruments which are currently measuring total solar irradiance (TSI/solar constant), and the Geostationary Earth Radiation Budget (GERB) instrument which will be flown on the METEOSAT Second Generation (MSG) satellite, scheduled for launch in October 2000. He indicated that Level 1 data from DIARAD/VIRGO had to be corrected for drift/aging of the detectors in some channels. Corrected data from these instruments are available from 1996 to the present and show a slow increase in TSI related to the solar activity. DeWitte

reported that the development of GERB processing systems was on schedule. Design and coding of main processing modules was complete. Work on processing systems for SEVIRI, which will serve as an imager for GERB and will fly on the same platform, was also on schedule. Processing systems for GERB/SEVIRI draw heavily on the corresponding CERES systems. Cloud property retrieval, scene identification, and spectral unfiltering systems for GERB/SEVIRI are closely following those developed for CERES processing. DeWitte also indicated that a delay in the launch of MSG was possible.

Bing Lin (Hampton University) presented results of a study of the variations of cloud amounts over tropical western Pacific (TWP) and tropical eastern Pacific (TEP) derived from multiple sensors on board the TRMM satellite. The study was initiated to examine in greater detail the finding by R. Cess that SWCRF/LWCRF ratio over TWP was significantly higher during the 1998 El Nino than during the ERBE period. Lin found almost no relationship between total cloud amount and the southern oscillation index (SOI). Better correlations were found when cloud amounts in low, middle, and high layers were examined separately. Clouds over TEP showed stronger correlations than those over TWP. Significant decrease in high clouds and increase in low clouds was found over TEP at the end of 1998 El Nino suggesting that TEP was dominated by subsidence toward the end of this episode.

Takmeng Wong (LaRC) presented results from a stochastic quality assurance algorithm applied to the entire 14-year record of ERBE non-scanner data. This algorithm was developed for minimizing errors in satellite-derived global fields caused by inadequate temporal sampling. After 1992, only non-scanner instruments on the ERBS satellite provided useful radiation budget data. Inadequate temporal coverage provided by a single satellite makes these data susceptible to large biases, especially away from the tropics. Wong showed that by screening out regions which have large time sampling errors, this algorithm enhances the accuracy of the monthly means. This method would be directly applicable to CERES data from TRMM because TRMM is also flying in a low-inclination precessing orbit, and flew alone for a considerable length of time.

Anand Inamdar of SIO (representing **V. Ramanathan**) presented results from a study of the atmospheric greenhouse effect (G_a) for the window and non-window regions. The non-window region was split further into the vibration-rotation and pure rotation bands. Inamdar examined the interannual variability of G_a using data from Nimbus-7 (1979-1987), ERBE (1985-1989), and CERES ERBE-like (ES-8) data for Jan.-Aug. 1998. He examined the relationship between surface temperature and G_a over tropical oceans and showed the latitudinal variation of this relationship at high latitudes. Inamdar also presented results showing sensitivity of G_a to perturbations in the moisture profile and concluded that the atmosphere was slightly drier and less cloudy in 1998 compared to earlier years.

Shi-Keng Yang of NOAA/National Centers for Environmental Prediction, NCEP (representing **Jim Miller**) presented a comparison of outgoing LW radiation (OLR) fields over tropical oceans (20N - 20S) from NCEP reanalyses versions 1 and 2 (R1 and R2), Atmospheric Model Intercomparison Project (AMIP II) runs with corresponding fields from ERBE, CERES ERBE-like product, and NOAA AVHRR. He also described recent changes incorporated into the NCEP reanalysis system. Time series of OLR from these sources showed significant differences, with R2 showing the highest values, and AMIP II runs the lowest. None of the model results showed the significant increase of OLR for 1998 as shown by CERES data relative to ERBE. Yang examined sea surface temperature records from 70's, 80's, and 90's and found a slight increase from 70's to 90's. Comparisons of layer-by-layer clouds between models and ISCCP showed that model clouds were generally higher/colder. Comparisons of layer-by-layer moisture in R2 with NVAP data showed the model to be drier. Yang concluded that upper tropospheric humidity was a stronger modulator of OLR than the clouds.

Educational Outreach

Lin Chambers (LaRC) reported that over 480 schools from all 50 states and over 35 countries are now participating in the Students' Cloud Observations On-Line (S'COOL) program.